Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	GN Docket No. 12-268

COMMENTS OF QUALCOMM INCORPORATED ON PUBLIC NOTICE TO SUPPLEMENT THE RECORD ON THE 600 MHz BAND PLAN

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SUMMARY

Qualcomm appreciates the opportunity to supplement the record in this proceeding by providing additional technical input in response to the Wireless Telecommunications Bureau's Public Notice (the "WTB PN"), which seeks comment on two variations of the "Down from 51" band plan: (i) a "Down from 51 Reversed" ("DF51 Reversed") Frequency Division Duplex ("FDD") band plan in which the uplink and downlink portions of the band are reversed, that is, the downlink is placed in the upper portion of the 600 MHz band; and (ii) a "Down from 51 TDD" band plan comprised of unpaired Time Division Duplex ("TDD") blocks. In these comments, Qualcomm explains its technical view that the two band plan variations are sub-optimal because they: (i) waste prime mobile broadband spectrum on a guard band, which would be especially unwise because the wasted spectrum is among the small amount of spectrum in the 600 MHz band that is well suited for uplink; (ii) introduce harmonics and spurious products that would interfere with operations in other bands that will be simultaneously active within the mobile device, and (iii) create other significant technical issues that would negatively impact mobile device size and performance, wireless network design, and the Commission's goal of enabling market variation.

In contrast, Qualcomm recommends a straight "Down from 51" ("DF51") FDD band plan in which a 25 MHz-wide uplink portion of the band is placed directly adjacent to the Lower 700 MHz A block, followed by a 10 to 12 MHz duplex gap and then a 25 MHz-wide downlink portion, with the remaining spectrum allocated for Supplemental Downlink ("SDL"), because this band plan avoids all of the crippling problems that the DF51 Reversed band plan and the TDD band plan would introduce. Qualcomm reached this conclusion based primarily on the following four technical factors.

First, both the DF51 Reversed band plan and the TDD band plan require the placement of a guard band at the upper end of the 600 MHz band, which wastes spectrum that is much better suited for licensed uplink operations. Particularly because it is uncertain how much spectrum an incentive auction will recover, relegating a 10 MHz swath of prime spectrum to a guard band is inefficient and wasteful. Moreover, if the guard band were less than 10 MHz, it is likely that there would have to be restrictions placed through the standards process on the Band 12 (*i.e.*, the Lower 700 MHz A block) uplink. The Commission should not waste valuable 600 MHz spectrum that is best suited for uplink, and by all means, the agency should not taken any action that could jeopardize Band 12 uplink operations.

Second, both the DF51 Reversed band plan and the TDD band plan increase the number of bands that will be jammed when they are simultaneously operating within the device; this includes critically important global positioning bands, the 2.4 GHz unlicensed Wi-Fi band, and licensed mobile bands such as PCS, WCS, and the BRS/EBS bands. Indeed, Qualcomm has explained repeatedly that harmonics and spurious products from 600 MHz uplink operations below 673 MHz would create crippling intra-device interference and should be avoided.

Third, both the DF51 Reversed band plan and the TDD band plan place uplink operations closer to broadcast TV receivers and directly adjacent to Wireless Medical Telemetry Services ("WMTS") and radio astronomy stations in Channel 37 and thus increase the potential for harmful interference to these services when compared to the straight DF51 plan recommended by Qualcomm that places downlink operations adjacent to these three services, which are far more compatible.

Fourth, both the DF51 Reversed band plan and the TDD band plan would be less amenable to accommodating market variation than the straight DF51 plan. The two plans would

vary the uplink spectrum in regions of the country that recover less spectrum from TV broadcasters, but Qualcomm has calculated that full power TV broadcast stations could cause interference to mobile base station receivers (*i.e.*, uplink operations) located more than 310 miles (or 500 km) away. This would substantially limit market variation where it is likely to be needed the most, such as along the eastern coast of the continental United States, and also complicate coordination with Canada and Mexico.

There are additional technical problems specific to each plan. For example, the DF51 Reversed band plan introduces the possibility of intermodulation products interfering with the mobile uplink because the DF51 Reversed plan places mobile uplink operations in between TV stations and mobile downlink operations. A TDD band plan make inefficient use of the limited portion of the band that is best suited for uplink operations, *i.e.*, the top 25 MHz, because it combines uplink and downlink operations throughout the entire band. After wasting approximately 10 MHz on a guard band, a TDD plan would mix downlink with uplink operations in the remaining 15 MHz, further limiting utilization of the most desirable uplink spectrum. Moreover, the number of spectrum blocks that need to be coordinated to limit inter-band interference is maximized by the use of TDD, since uplink operations are in every block of spectrum. The fact that a TDD plan may (depending on how it is constructed) be supported by a narrower antenna bandwidth is far outweighed by the many technical problems highlighted above and detailed herein.

The straight DF51 band plan that Qualcomm recommends provides the technically optimal use of the spectrum to be cleared via the incentive auction process when one considers the Commission's core goals for the 600 MHz band plan framework: "utility, certainty, interchangeability, quantity and interoperability," *see* WTB PN at 1 & *NPRM* at ¶¶ 123-24,

because the straight DF51 band plan can be successfully integrated into existing smartphone and tablet form factors using RF components based upon known technology that is expected to be made available by the time the repurposed spectrum is expected to be placed online. Such a band plan also could ensure that the auctioned spectrum blocks are spectrally identical and thus fully interchangeable or fungible.

Thus, a band plan comprised of a 25 MHz uplink band placed directly adjacent to the Lower 700 MHz A (uplink) block, followed by an 10 to 12 MHz duplex gap, then a 25 MHz downlink band — with the remainder of the band used for SDL — will make technically optimal use of the 600 MHz band and ensure that auction winners can rapidly deploy services on the new spectrum using devices that are comparable in size to the devices in use today and can support simultaneous operations using multiple technologies in multiple bands. Both in the U.S. and around the world, carriers are experiencing far more traffic on the downlink than uplink, and as a result, SDL is receiving considerable traction to help ease the spectrum crunch. As a result, we believe that this band plan can enable a very successful auction.

Qualcomm appreciates the opportunity to supplement the record and will continue to work closely with all interested stakeholders to drive towards consensus on as many of the technical issues as possible, so that the FCC can adhere to the schedule set out in the *Incentive Auction NPRM* and achieve its stated objectives.

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COMMENTS OF QUALCOMM INCORPORATED ON PUBLIC NOTICE TO SUPPLEMENT THE RECORD ON THE 600 MHZ BAND PLAN

QUALCOMM Incorporated ("Qualcomm") hereby comments on the Wireless Telecommunications Bureau's Public Notice[1] seeking to supplement the record on the 600 MHz band plan and specifically seeking technical input on two variations of the "Down from 51" band plan: (1) a "Down from 51 Reversed" ("DF51 Reversed") Frequency Division Duplex ("FDD") band plan variation where the uplink and downlink portions of the band are reversed, that is, the downlink is placed in the upper portion of the 600 MHz band; and (2) a "Down from 51 TDD" band plan comprised of unpaired Time Division Duplex ("TDD") blocks.

Qualcomm explains in these comments that each of these band plan variations are sub-optimal because they: (i) waste prime mobile broadband spectrum on a guard band, which would be especially unwise because the wasted spectrum is among the small amount of spectrum in the 600 MHz band that is well suited for uplink; (ii) introduce harmonics and spurious products that would interfere with operations in other bands that will be simultaneously active

[1] *See* FCC Public Notice DA 13-1157, *Wireless Telecommunications Bureau Seeks To Supplement The Record On The 600 MHz Band Plan* (May 17, 2013) ("WTB PN"); *see also* Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, GN Docket No. 12-268, *Notice of Proposed Rulemaking*, FCC 12-118 (rel. Oct. 2, 2012) ("*NPRM*").

within the mobile device, and (iii) create other significant technical issues that would negatively impact mobile device performance and network design.

Moreover, neither plan allows for very much market variation because both plans would allow TV broadcast operations to occupy the same channel as mobile uplink operations in adjacent markets, which according to Qualcomm's calculations, would require a separation distances of more than 300 miles in order to avoid TV co-channel interference to mobile base station receivers.

In contrast, the straight "Down from 51" ("DF51") FDD band plan that Qualcomm recommends[2] — where a 25 MHz-wide uplink portion of the band is placed directly adjacent to the Lower 700 MHz A block, followed by a 10 to 12 MHz duplex gap and then a 25 MHz-wide downlink portion — avoids these problems. As explained below, the straight DF51 band plan provides the optimal use of the spectrum to be cleared via the incentive auction process when one considers the "five key policy goals" for the 600 MHz band plan framework: "utility, certainty, interchangeability, quantity and interoperability,"[3] because the straight DF51 band plan can be successfully and most readily integrated into existing smartphone and tablet form factors,[4] and it can help ensure that each of the spectrum blocks to be auctioned are spectrally identical and thus fully interchangeable or fungible.[5] Such a band plan design will ensure that auction winners can rapidly deploy services on the new spectrum using devices that are comparable in size to the devices in use today and can support simultaneous operations using multiple

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2 *See* Comments of Qualcomm Inc. (Jan. 25, 2013) ("Qualcomm Comments") at i-v, 4-22, *and see* Reply Comments of Qualcomm Inc. (Mar. 12, 2013, re-filed with corrected page numbers on Apr. 3, 2013) ("Qualcomm Reply Comments") at i-iii, 17-24.

3 WTB PN at 1. *See also NPRM* at ¶¶ 123-24.

4 *See generally* Qualcomm Comments and Qualcomm Reply Comments.

5 *See id.*; WTB PN at 4 ("[W]e must implement guard bands to ensure all spectrum blocks are as technically and functionally interchangeable as possible."). *See also NPRM* at ¶ 125.

technologies in multiple bands. Furthermore, this approach to band plan design will help enable a very successful 600 MHz forward auction because it will ensure that forward auction bidders do not discount their bids due to known technical liabilities in the band plan.

As detailed below, Qualcomm's analysis shows that the DF51 Reversed and the TDD band plans set out in the WTB PN cannot be successfully incorporated into smartphones and tablets without negatively impacting the utility of those devices and without increasing the cost, size, power consumption, and complexity of the devices. FCC adoption of either of these sub-optimal band plans would pose unnecessary implementation difficulties for the wireless industry, thereby adversely impacting wireless subscribers, and likely lead to lower bids from forward auction participants as opposed to what can be achieved with a straight DF51 plan.

DISCUSSION

I. A Straight "Down From Channel 51" FDD Band Plan Similar To The Plan Proposed In Figure 12 Of The FCC's *NPRM* Can Be Successfully Implemented

Qualcomm's methodical technical analysis of potential 600 MHz band plans over the past nine months leads us to reaffirm our recommendation that the FCC implement a 2 x 25 MHz FDD band plan with a narrow duplex gap of at least 10 MHz. This plan is similar to the plan shown in Figure 12 of the *Incentive Auction NPRM* copied below.

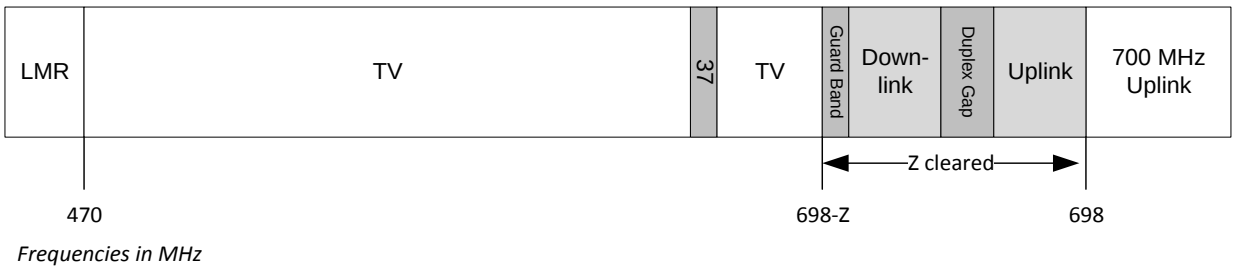

Figure 12 in *Incentive Auction NPRM*

The 2 x 25 MHz FDD band plan with a duplex gap of at least 10 MHz can be readily incorporated into smartphones and other mobile devices in form factors comparable to the

devices in use today and using RF components that will become available in the very near future. A duplex gap of at least 10 MHz is needed to avoid interference between mobile downlink and uplink based on the attenuation filters that Qualcomm understands will become available by the time that the auction ends, based on known technology. A guard band of approximately 10 MHz between the last full power (*i.e.*, 1 MW) TV station and the downlink block is the minimum needed to prevent a TV station from saturating a mobile device that is trying to receive.[6]

Qualcomm strongly believes that the auction is most likely to be successful if the 600 MHz band plan is designed such that it can be successfully incorporated into devices comparable in size and weight to today's tightly constrained devices that already support multiple bands. To keep mobile device size comparable to today's smartphone form factor, it is highly desirable that the band plan for 600 MHz enable re-use of the existing 700 MHz band antenna for 600 MHz band operations, as explained below.

A. Analysis Of The Impact Of 600 MHz Harmonics And Spurious Products Demonstrates That The 25 MHz Block Of Spectrum At The Top End Of The 600 MHz Band Is Best Suited For Uplink Operations Exclusively

Qualcomm's comments and reply comments in this proceeding provided a very detailed analysis of the signal harmonics and spurious products generated as a consequence of the selected UE uplink frequencies that potentially impact concurrent mobile operations in higher bands and found that the top five analysis blocks that span from 673 to 698 MHz are best suited to support uplink operations.[7]

While uplink transmissions in any of the 24 analysis blocks that span the 120 MHz from 578 to 698 MHz generate harmonics and spurious products that could jam licensed mobile, unlicensed Wi-Fi, and/or positioning receive bands operating in higher frequency bands, the top

6 *See* Qualcomm Comments at 4-15; Qualcomm Reply Comments at 17-23.

7 *See* Qualcomm Comments at 7-13; Qualcomm Reply Comments at 19-23.

five analysis blocks of the 600 MHz band (*i.e.*, analysis block 20 to 24) are free from lower order harmonics and spurious products, and thus best suited to support uplink operations.[8]

It is particularly important to appreciate the impact of 600 MHz uplink signals on higher-frequency unlicensed Wi-Fi bands, higher-frequency licensed mobile bands (*e.g.*, AWS, PCS and BRS/EBS operations), and higher-frequency positioning bands because mobile devices that incorporate the 600 MHz band will operate in multiple frequency bands at the same time. In fact, today's mobile devices routinely communicate via a licensed mobile band and/or unlicensed Wi-Fi band while concurrently receiving positioning data at very low signal levels. In the very near future, mobile devices will use Carrier Aggregation ("CA") technology to bond two separate spectrum bands together (*e.g.*, 600 MHz and PCS or BRS/EBS) to create a wider band for operations and, hence, increased throughput.[9] This is a key feature of LTE-Advanced and is being implemented by big and small carriers alike all over the world. Accordingly, simultaneous operation in multiple bands is critical to providing users the mobile broadband experience they have come to rely upon.

Qualcomm has conclusively demonstrated in this proceeding that harmonics and spurious products from 600 MHz uplink signals will negatively impact operations in other higher bands (including sensitive positioning bands) that are simultaneously active on the same mobile device. Analysis blocks 1 to 19, which span from 578 to 668 MHz, are particularly poorly suited for 600 MHz uplink operations.

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[8] The top 5 analysis blocks have only a substantially lower power 8th order harmonic generated by uplink transmissions between 673 to 698 MHz that may impact unlicensed operations at 5 GHz.

[9] Mobile operators in the U.S. and abroad will soon be deploying CA technology, which is part of the LTE-Advanced standard. CA allows an operator to build a wider mobile broadband pipe by bonding together two spectrum bands to create one wider band for operations. Thus, concurrent support for multiple bands, which will provide substantial capacity increases, is central to offering CA.

The following list provides a sample of the bands that may be jammed by 600 MHz uplink operations:

1. **PCS**. Third order harmonics from 600 MHz mobile device transmissions within analysis blocks 14 to 18 can jam the PCS receive band;
2. **Position Location Bands**. Second order harmonics from 600 MHz mobile uplink transmissions within analysis blocks 1 to 4 and analysis blocks 8 to 10 can jam the Global Positioning System ("GPS") L2 and L5 bands and Global Navigation Satellite System ("GNSS") L2 band positioning receivers, which operate from 1226.577 to 1228.623 MHz, 1164.45 to 1188.45 MHz, and 1242.427 to 1249.136 MHz, respectively.
3. **2.5 GHz BRS/EBS Band**. Fourth order harmonics from 600 MHz mobile device transmissions in analysis blocks 10 to 19, a 60 MHz span, can impact BRS/EBS (Band 41) operations in the 2.5 GHz band.
4. **WCS Band.** Fourth order harmonics from 600 MHz mobile device transmissions in analysis blocks 2 and 3 can impact the WCS band, and
5. **Wi-Fi Band**. Fourth order harmonics from 600 MHz mobile device transmissions in analysis blocks 5 to 9 would impact unlicensed Wi-Fi operations at 2.4 GHz.[10]

Qualcomm's detailed analysis of spurious products generated by 600 MHz uplink operations corroborates the harmonics analysis.[11] Table 7 in Qualcomm's reply comments provided all of the modulation products that could impact operations in bands above 600 MHz. The list is overwhelming.[12]

There is no question that the placement of 600 MHz uplink operations in analysis blocks 1-19 will generate harmful spurious products in the higher bands noted above and that analysis

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10 *See* Qualcomm Comments at 11, Table 2; Qualcomm Reply Comments at 19-20.

11 *See* Qualcomm Comments at 11-13; Qualcomm Reply Comments at 21-23.

12 *See* Qualcomm Reply Comments at 23 (listing dozens of spurious products that 600 MHz operations would place into the simultaneously active higher-frequency bands).

blocks 1 to 9 are particularly bad for WAN, geo-location and 3.5 GHz operations. There also can be no question that these spurious products can be even more harmful than the impact of harmonic signals discussed above. Thus, as Qualcomm has explained, the lower portion of the 600 MHz band is a particularly poor swath of spectrum in which to place uplink operations, and uplink operations should be kept in the upper portion of the spectrum band, specifically within analysis blocks 20 to 24 that run from 672 to 698 MHz.

Given that uplink operations are best supported in the top five 5 MHz analysis blocks, which is a limited amount of spectrum when one considers the entirety of the 120 MHz band that the FCC has targeted in this proceeding, Qualcomm believes that TDD operations (where uplink and downlink transmissions occur at different times on the same piece of spectrum) are not well suited for a 600 MHz band plan. In other words, because the prime spectrum for uplink operations is limited, it is not optimal to also enable downlink operations in that limited part of the band particularly where there is ample other spectrum in the 600 MHz band that is particularly well suited for downlink operations. And, as it turns out, the significant difficulties with co-channel interference from TV broadcast operations to the mobile base station receiver also necessitate limiting the amount of uplink spectrum in this band.

B. Today's Smartphone Form Factors Limit The Efficient Operating Bandwidth Of A 600 MHz Antenna System To Approximately 62 MHz

Qualcomm also analyzed the antennas that could be used to support operations in the 600 MHz band and explained that it is particularly desirable that the paired operations within the band be supported by a single antenna system, preferably the same antenna system already currently used in smartphones to support 700 MHz operations.[13] There simply is no spare space in today's smartphones for an additional large antenna system.

[13] *See* Qualcomm Comments at 13-15; Qualcomm Reply Comments at 24-25.

Qualcomm has previously explained that adding a new low frequency band requires either that a relatively large antenna system be added, or an existing antenna (such as that used to support Band 12, 17, or 13 in the 700 MHz band) be tuned to operate in the lower frequency band.[14] It is important to appreciate that an antenna designed to support 600 MHz operations exclusively could require considerably more volume than current 700 MHz antennas and substantially challenge current smartphone form factors. In other words, were the FCC's 600 MHz band plan to cause the use of a separate antenna system for 600 MHz, smartphones may have to become much larger in order to perform acceptably.[15]

Retuning a 700 MHz antenna does have its costs. A currently implemented 700 MHz band antenna, *i.e.*, an antenna that achieves a 6% 1 dB efficiency bandwidth at 710 MHz, has its 1 dB efficiency bandwidth reduced to approximately 4.6 % when it is retuned to operate at 660 MHz. Qualcomm agrees with Ericsson and IWPC that current mobile device filter technology is limited to a maximum passband of approximately 4% of the passband's center frequency.[16] Thus, Qualcomm's proposed FDD band plan that is 2 x 25 MHz with a 10 to 12 MHz duplex gap has been derived as the maximum bandwidth for a single duplexer implementation based on the ~4% maximum filter bandwidth limitation.

A straight DF51 2 x 35 MHz (or wider) FDD band plan at 600 MHz would require mobile devices to incorporate both an additional large antenna system and a second duplexer. In

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14 *See* Qualcomm Reply Comments at 24-25.

15 *See* D.F. Sievenpiper, et al., "Experimental Validation of Performance Limits and Design Guidelines for Small Antennas," IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION (Jan. 2012). The maximum dimension of the ground plane on the circuit board is the controlling aspect of the bandwidth * efficiency product of the device antenna system at 600 MHz, and the fractionally wider bandwidth of FDD operations in the 600 MHz band as compared to 700MHz causes either a larger device form factor or a loss in the efficiency of the antenna system.

16 *See NPRM* at n.250.

Qualcomm's view, this would unacceptably increase the size (and cost) of today's space constrained smartphones. On the other hand, a straight DF51 2 x 35 MHz plan that divides the band into two adjacent segments that lie above Channel 37 — a 2 x 15 MHz segment and a 2 x 20 MHz segment — could be supported by a single antenna provided that an adequate tuner is available.[17] While this plan would allow the FCC to auction more paired spectrum (assuming that it can be recovered from TV broadcast licensees), it would require mobile devices to incorporate a second duplexer for 600 MHz operations and, for the reasons described in Section I.A above, lead to intra-device interference if an operator implements CA with: (i) the lower 5 MHz uplink portion of the paired 600 MHz band and the upper portion of the PCS band, or (ii) the lower 10 MHz uplink portion of the paired 600 MHz band and the BRS/EBS band. The single antenna also could not support simultaneous operation on the two paired bands.

These problems are not present with the straight DF51 2x 25 MHz FDD band plan with a 10 to 12 MHz duplex gap that Qualcomm recommends. Qualcomm believes that this band plan can be implemented with a minimal increase in antenna volume and possibly without a tuner for some form factors.

C. The FCC Should Implement A Straight DF51 2 x 25 MHz FDD Band Plan With Any Additional Spectrum Allocated For Supplemental Downlink Use

Based on its detailed and multi-faceted technical analyses conducted over the past nine months, Qualcomm is at this point in time even more confident about the technical feasibility of using the 600 MHz band for FDD operations, that is, with 2 x 25 MHz situated in the uppermost portion of the band along with a 10 MHz duplex gap, with any additional spectrum allocated for Supplemental Downlink ("SDL") operations. Such a plan is shown in Figure 1 below.

[17] A TDD band plan would require a tuner as well.

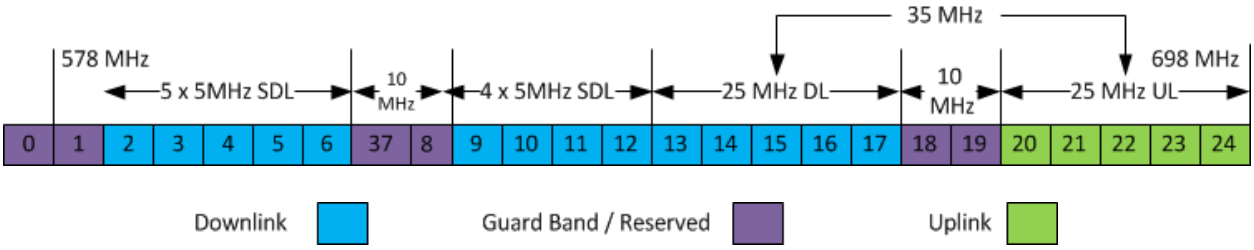

Figure 1. Qualcomm's Recommended 600 MHz Band Plan

SDL is particular useful because the traffic on mobile networks is increasingly asymmetrical.[18] Mobile broadband traffic data shows that the ratio of downlink to uplink can be 10:1 or greater.[19] And, by placing SDL spectrum blocks adjacent to the downlink portion of the FDD portion of this band plan, there is no need to provide a guard band between the downlink blocks, as the FCC has recognized.[20] By locating the uplink portion of the 600 MHz band in the uppermost portion of the band, there also is no need to provide a guard band between the 600 MHz uplink band and the Lower 700 MHz A Block — because like operations in adjacent bands are spectrally compatible, as the FCC well knows.[21]

SDL technology will create opportunities in the U.S. and around the world because it allows wireless carriers to utilize unpaired spectrum bands in conjunction with existing paired

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18 *See NPRM* at ¶ 134 (seeking comment on the extent to which mobile broadband traffic today is asymmetrical).

19 *See, e.g.*, Hossein Falaki, *et al*. "A First Look at Traffic on Smartphones" IMC 2010 Melbourne (Nov. 2010) (uplink traffic volume measured to be more than 10 times the downlink traffic for certain users, with a average uplink to downlink ratio of 6:1).

Qualcomm also is concerned that creating additional FDD pairs in any portion of the lower nineteen analysis blocks of the 600 MHz band would not be a successful arrangement. Doing so would create a stark inequality between the lower FDD pairs and the straight DF51 2 x 25 MHz FDD pair at the upper end of the 600 MHz band that does not cause interference to other bands that may be in simultaneous use on the device.

20 *See NPRM* at ¶ 135.

21 *See id.* at ¶ 154.

bands to substantially improve mobile broadband data download performance.[22] As described above, the asymmetry of mobile broadband data demand makes the use of SDL particular appealing, and it is unquestionably spectrally efficient for it enables carriers to meet users' growing mobile data download demands. In fact, AT&T plans to deploy its recently acquired lower 700 MHz D and E block spectrum assets as SDL.[23]

* * *

Qualcomm has conducted extensive and multi-faceted technical studies of the 600 MHz band to determine how best to incorporate the band into today's smartphones and other mobile devices that consumers love. These studies have confirmed and re-confirmed what Qualcomm originally proposed – that the superior use for this band is the straight DF51 FDD band plan, comprised of a 25 MHz uplink band (located directly adjacent to the Lower 700 MHz A block), followed by a 10 MHz duplex gap and then a 25 MHz downlink band. To the extent the forward auction permits the Commission to repurpose for mobile broadband operations more than 12 TV broadcast channels, the additional spectrum should be allocated and auctioned for SDL use.

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[22] Last month, the Decision of the Electronic Communications Committee ("ECC") of the European Conference of Postal and Telecommunications Administrations ("CEPT") to implement SDL in the L-band was endorsed by the 30 European Administrations, and the ECC Decision is expected to be published in November 2013.

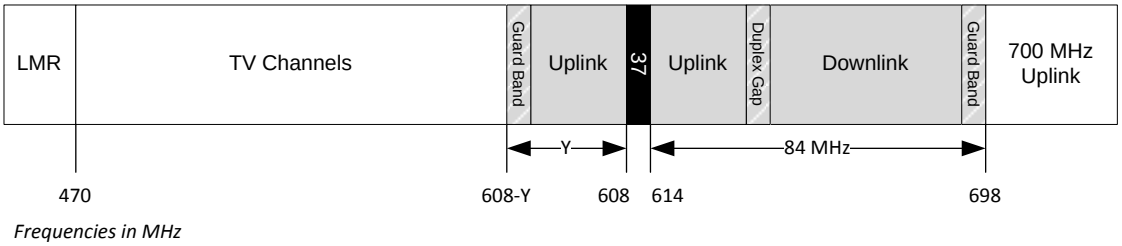
[23] *See* Qualcomm Press Release, *Qualcomm Announces Agreement for Sale of 700 MHz Spectrum Licenses* (Dec. 20, 2010) *available at* http://www.qualcomm.com/news/releases/2010/12/20/qualcomm-announces-agreement-sale-700-mhz-spectrum-licenses (announcing sale of "Lower 700 MHz D and E Block (Channel 55 and 56) unpaired U.S. spectrum licenses to AT&T for $1.925 billion"). *See also AT&T Agrees to Acquire Wireless Spectrum from Qualcomm, Spectrum To Help AT&T Continue To Enhance The Mobile Broadband Experience Nationwide* (Dec. 20, 2010) *available at* http://www.qualcomm.com/news/releases/2010/12/20/att-agrees-acquire-wireless-spectrum-qualcomm (announcing that the spectrum to be used for SDL in the 700 MHz band "covers more than 300 million people total nationwide: 12 MHz of Lower 700 MHz D and E block spectrum covers more than 70 million people in five of the top 15 U.S. metropolitan areas — New York, Boston, Philadelphia, Los Angeles and San Francisco; 6 MHz of Lower 700 MHz D block spectrum covers more than 230 million people across the rest of the U.S.").

In contrast to the straight DF51 band plan recommended by Qualcomm, the two band plans on which the FCC seeks comment in the recently issued WTB PN are suboptimal as explained below.

II. The DF51 Reversed Band Plan Suffers From A Number Of Crippling Technical Problems That Do Not Exist With The Straight DF51 Plan

Qualcomm explains in this section of its comments the many technical problems that would be created by implementation of the DF51 Reversed band plan.

Down from 51 Reversed, more than 84 MHz cleared



A. The DF51 Reversed Plan Necessitates A Guard Band At The Upper End Of The 600 MHz Band And Thus Wastes Spectrum Best Suited For Uplink Operations

As Qualcomm explains in Section I.A above,[24] the 25 MHz block of spectrum at the upper end of the 600 MHz band is best suited to support uplink operations, and this uplink block can be placed directly adjacent to the existing Lower 700 MHz (uplink) A block in the straight DF51 band plan without any guard band.

The DF51 Reversed band plan, in contrast, would place downlink spectrum at the upper end of the 600 MHz band and thus necessitate the use of a guard band of approximately 10 MHz at the uppermost portion of the band to protect the mobile device downlink operating in the

[24] *See also* Qualcomm Comments at 7-13; Qualcomm Reply Comments at 19-23.

uppermost portion of the 600 MHz band from the Lower 700 MHz A block uplink operations.[25] This 10 MHz guard band would waste 40 percent of the spectrum (*i.e.*, 10 MHz out of the 25 MHz) that is best suited for uplink operations and thus not make optimal use of that spectrum.

Moreover, if the guard band were less than 10 MHz, there likely would be efforts to place restrictions on the Band 12 (Lower 700 MHz A block) uplink via the 3GPP standards process. The FCC should not waste valuable 600 MHz spectrum that is ideal for uplink on a guard band, and the agency should not take any action that could jeopardize Band 12 uplink operations.

B. The DF51 Reversed Plan Would Increase The Number of Jammed Bands That Are Simultaneously Operating Within The Device

The DF51 Reversed band plan would place uplink operations in a portion of the band that would create intra-device interference with other bands that will be simultaneously active on the device, as explained in Section I.A above. These bands include 2.4 GHz unlicensed Wi-Fi operations, GPS and GNSS bands used for position location, and licensed PCS, WCS, and BRS/EBS operations, among others. Limiting the ability of 600 MHz mobile devices to operate simultaneously at 2.4 GHz for unlicensed Wi-Fi operations or the foregoing positioning bands would impair the value of the auctioned spectrum. And, preventing 600 MHz devices from using CA along with the PCS, WCS, and BRS/EBS bands also would impair the value of the spectrum.[26] The DF51 Reversed band plan also introduces the possibility of intermodulation products interfering with the mobile device uplink because it places mobile uplink operations in between TV stations and mobile downlink operations.

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[25] *See* WTB PN at 3 n.19 ("Because the lower 700 MHz band is being used for mobile uplink operations while the upper 600 MHz band would be used for downlink operations under this model, we must create a guard band between the two bands to protect against interference.").

[26] *See, e.g.,* Section I.A, *supra*.

C. Uplink Operations In The Lower 600 MHz Band Would Increase The Potential Interference to Channel 37 Operations And TV Receivers

Placing uplink operations in the lower portion of the 600 MHz band adjacent to Channel 37 would increase the potential for interference to WMTS and radio astronomy operations and may require the addition of guard bands around Channel 37 to protect such operations. This problem is not present with the straight DF51 band plan that locates downlink operations directly adjacent to Channel 37.

Placing uplink operations in the lower portion of the 600 MHz band also increases the potential for interference from mobile uplink operations to TV receivers operating in the remaining TV spectrum. The potential need for a larger guard band at the low end of the 600 MHz band to protect TV receivers is not necessary with the straight DF51 band plan.

D. The DF51 Reversed Plan With A Variable Uplink Spectrum Would Not Accommodate Market Variation

The market variation diagrams on page 4 of the WTB PN for the DF51 Reversed band plan show a collection of band plans with variable uplink bands. A variable uplink band would be substantially less amenable to accommodating market variation when compared to a variable downlink band. In fact, the distances at which a full power TV broadcast signal will interfere with mobile broadband uplink operations is much greater than the distance at which full power TV broadcast signals will interfere with mobile downlink operations. Based on Qualcomm's calculations, the distances are approximately 500 km (or 310 miles) for TV to mobile uplink and as compared to approximately 100 km for TV to mobile downlink.

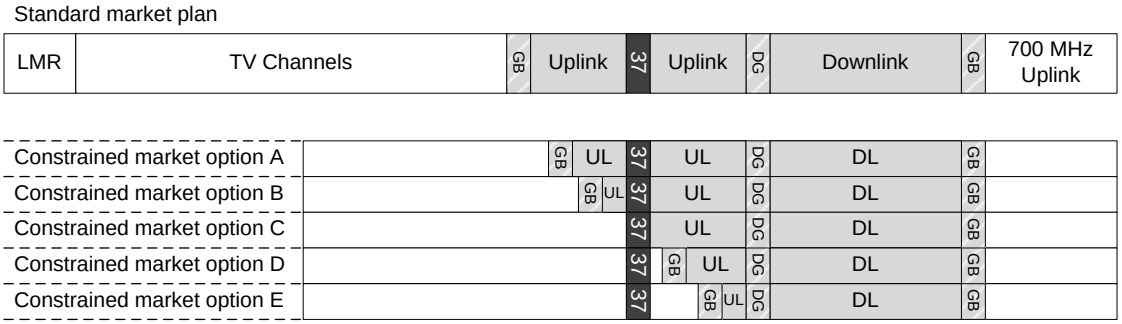
Accordingly, the DF51 Reversed band plan would be worse at accommodating market variation than the straight DF51 plan Qualcomm recommends. Nonetheless, Qualcomm strongly supports a national 600 MHz band plan as it could eliminate these types of interference issues.

Furthermore, the FCC should adopt technical rules that enable repacking to achieve the required minimum spectrum.

III. A TDD Band Plan Suffers From Equally Troubling Technical Problems That Are Overcome By The Straight DF51 Band Plan, Specifically The 2x25 MHz FDD Plan

In this section, Qualcomm describes the many technical problems that would be created by the implementation of a TDD band plan, such as that shown below.

Market Variation in Down from 51 Reversed, more than 84 MHz cleared



Among other problems, a TDD band plan is perhaps the worst plan to accommodate market variation because a TDD plan would place mobile uplink operations throughout the entire 600 MHz band and thus subject mobile base stations to harmful interference from full power co-channel TV broadcast stations up to 500 km (or 310 miles) away. For this reason, the FCC should not allow uplink operations co-channel with TV stations operating in adjacent markets and should strive to develop a feasible national band plan like the straight DF51 band plan that Qualcomm proposes.

A. TDD Has Uplink and Downlink Operations In The Same Band Of Spectrum And Thus Requires A Guard Band At The Upper End Of The 600 MHz Band, Wasting Spectrum Best Suited For Uplink Operations Exclusively

As Qualcomm explained above,[27] the 25 MHz block of spectrum at the upper end of the 600 MHz band is best suited to support uplink operations due to the harmful harmonics and spurious products that uplink operations below 673 MHz would generate, and this uplink block can be placed directly adjacent to the existing Lower 700 MHz (uplink) A block without any guard band.

In contrast, a TDD band plan would place downlink (and uplink) operations at the upper end of the 600 MHz band and thus, like the DF51 Reversed band plan, requires the placement of a guard band of approximately 10 MHz at the upper end of the band to protect the 600 MHz mobile device receivers from interference caused by Lower 700 MHz A block uplink operations. Such a guard band would waste a large portion, *i.e.*, 40 percent, of the spectrum that is best used for exclusive uplink operations because the portion of the band below 673 MHz is particularly poorly suited for uplink operations.

B. A TDD Plan Would Maximize The Number of Jammed Bands That May Be Simultaneously Operating Within The Mobile Device

A TDD band plan would have uplink operations throughout the 600 MHz band and thus maximize the number of jammed bands that may be simultaneously operating within the device. TDD usage would create intra-device interference with 2.4 GHz unlicensed Wi-Fi operations, GPS and GNSS bands used for position location, and licensed PCS, WCS, and BRS/EBS operations — all of which may be simultaneously active on the same mobile device. Preventing 600 MHz devices from simultaneously using 2.4 GHz Wi-Fi or the foregoing positioning bands would impair the value of the spectrum, and preventing 600 MHz devices from performing CA

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[27] *See* Section I.A *infra.*

with operations in the PCS, WCS, and BRS/EBS bands also would impair the value of the spectrum. Indeed, in order to provide the user experience that today's mobile user demands, it is essential that smartphones and tablets operate seamlessly in unlicensed, licensed and positioning bands simultaneously.

C. Uplink Operations Throughout The 600 MHz Band Also Would Increase The Potential Interference to Channel 37 Operations And TV Receivers

Having uplink operations throughout the 600 MHz band, including the lower portion of the band close to Channel 37 operations, would increase the potential for interference to WMTS and radio astronomy operations and may require the addition of guard bands around Channel 37 to protect such operations. This problem is not present with the straight DF51 band plan proposed by Qualcomm that locates downlink operations directly adjacent to WMTS and radio astronomy operations in Channel 37.

Placing uplink operations in the lower portion of the 600 MHz band also increases the potential to cause interference to TV receivers operating in the remaining TV spectrum. This therefore introduces the need for a larger guard band at the low end of the 600 MHz band to protect TV receivers than would be necessary for the straight DF51 band plan Qualcomm recommends, which places mobile downlink operations at the lowest end of the band.

D. A TDD Band Plan Would Not Allow For Market Variation Because Co-Channel TV Stations Interfere With Base Station Receivers 500 km Away

The market variation diagrams on page 6 of the WTB PN for the TDD band plan show a collection of TDD band plans for potential implementation in constrained markets. In practice, however, a TDD band plan would not allow for very much market variation because Qualcomm has calculated the distance at which a full power TV broadcast signal would interfere with mobile broadband uplink operations to be approximately 500 km (or 310 miles). As explained in Section II.D above, this is much greater than the 100 km distance at which full power TV

broadcast signals would interfere with mobile downlink operations. The difference between the interference distance to mobile uplink and to mobile downlink is so stark because the mobile downlink interference calculation benefits from the ground clutter that is not present for mobile base station antennas that are mounted tens of meters above ground level or greater.

Consequently, the TDD band plan would be worse than the straight DF51 plan Qualcomm recommends at accommodating market variation. Qualcomm thus recommends a national 600 MHz band plan because it would eliminate these types of interference issues.

CONCLUSION

For the foregoing reasons, the FCC should not implement a DF51 Reversed or TDD band plan. Both plans introduce serious technical challenges and many other problems that Qualcomm's proposed straight DF51 2 x 25 MHz FDD band plan was designed to avoid.

Qualcomm looks forward to continuing to work with the Commission and the wireless and broadcast industry stakeholders towards defining a band plan that will raise the greatest amount of money and can be readily incorporated into mobile devices that are comparable in size to those being used today.

Respectfully submitted,

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